REST FRAME OPTICAL SPECTROSCOPY OF DISTANT RADIO GALAXIES

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Abstract. We have searched for redshifted optical emission lines in the near-infrared from 17 distant radio galaxies (and the IRAS source FSC 10214+4724, Elston et al. 1993), using InSb array spectrometers at the KPNO and CTIO 4m telescopes. The redshifts range from 0.8 to 3.4. We detect lines in over a dozen cases, summarized in the table below.

For B2 0902+34 we detect [OIII]5007Å at z=3.39 at a flux consistent with the narrow band image of Eisenhardt and Dickinson (1992). This line accounts for virtually all of the observed broadband K flux in B2 0902+34, leaving a flat continuum characteristic of a protogalaxy.

In the other radio galaxies we detect Hα+[NII] emission, and in many cases the redshift is large enough so that the Lyα flux is available from optical spectroscopy. The reddening can be estimated from the ratio of Lyα/Hα. We typically find a ratio of 4, which when compared to the low density recombination ratio of 9 leads to $E_{(B-V)}$ = 0.1 and Av = 0.3 (rest-frame) using standard extinction curves (McCarthy, Elston and Eisenhardt 1992). This should be regarded as an upper limit to the reddening since multiple scatterings may contribute to the destruction of Lymanα. The net effect of the reddening and line flux correction to the continuum in these galaxies is to make the observed frame R-K colors 0.7 mag bluer while leaving the K magnitude virtually unchanged. These color changes imply substantially younger ages for the stellar populations in these galaxies, as the case of B2 0902+34 illustrates.

We also have data on the [NII]6548/6584Å, [0111] 4959/5007A, and [OII]3727Å lines in some cases, and are exploring the use of these in combination with UV lines to constrain the ionizing spectrum (e.g. using [0111] 5007/CIV1549). While the majority of the line profiles are narrow, in a few cases we see apparently broad profiles (a few thousand km/see) reminiscent of quasars, even though the objects possess no broad UV emission lines.

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References

Eisenhardt, P. and Dickinson, M.: 1992, *Ap.J.* 399, L47
Elston, R., McCarthy, P., Eisenhardt, P., Dickinson, M., Spinrad, H., Jannuzi, B. and Maloney, P.: 1993, *A.J.*, submitted
Lilly, S, J.: 1988, *Ap.J.* 333, 161
McCarthy, P. J., Elston, R., and Eisenhardt, P.: 1992, *Ap.J.* 387, L29

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Name	Redshift	Line Fluxes (10^{-17} erg/s/cm^2)	Comments
3C 22	0.937		Hα+[NII] possibly broad
3C 107	0.79		Hα not detected
3C 265	0.811		Hα detected
3C 257	2.474		Weak Hα detection
3C 352	0.806		Good Ha detection
3C 470	1.653		Hα not detected
B2 0902+34	3.395	1.1([0111]5007'	[0111] redshift = 3.386. Protogalaxy?
B3 0731+438	2.429	0.8(Hα)	[0111] also detected
B3 0903+428	0.907		Ha detected
MG 1744+18	2.281		Probable Ha detection, very extended
MRC 0156-252	2.09	1.5(Hα+[NII])	Weak Hα detection
MRC 0406-244	2.428	1.4(Hα+[NII])	[0111] also detected
MRC 1106-256	2.43	6.0(Hα+[NII])	
MRC 1138-262	2.17	13.(Hα+[NII])	Possibly broad profile
MRC 1324-262	2.28		Hα not detected
MRC 202$218	2.63	1.5(Hα+[NII])	Weak Hα detection
MRC 2139-292	2.55		Hα not detected

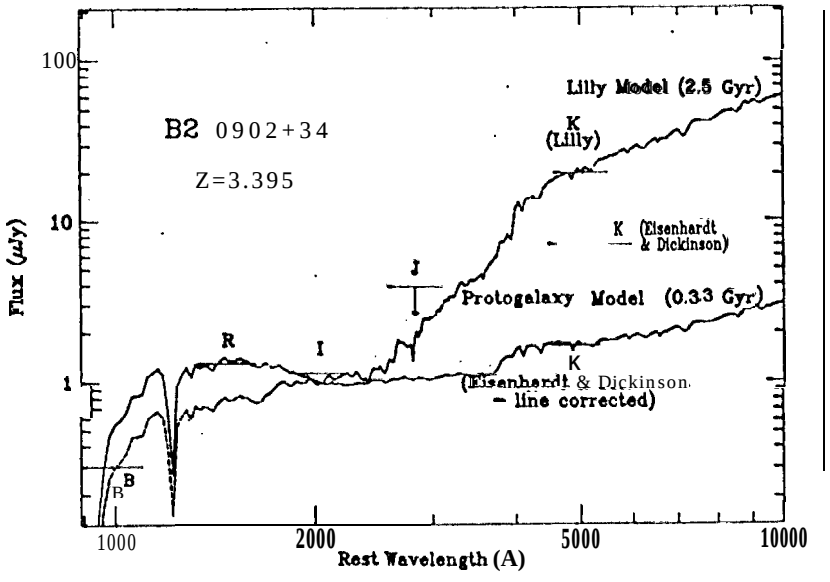

Fig. 1. The amount of observed K light (rest frame optical) in the redshift 3.4 radio galaxy B2 0902+34 has dropped dramatically after corrections to Lilly's original (1988) value, shown by the short horizontal bar at upper right. Eisenhardt and Dickinson's (1992) K measurement is shown by the horizontal bar at middle right, and after correcting for the [0111] 5007Å line flux the K light drops to the level shown at lower right. Instead of the 2.5 billion year old population favored by Lilly (dashed line), the corrected data are fit by a 300 million year old protogalaxy model (solid line).